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Samotlor Oilfield: Prospects for a Fading Supergiant

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A Research Paper

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Samotlor Oilfield: Prospects for a Fading Supergiant

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A Research Paper

This paper was prepared by 25X1
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Comments and queries are welcome and may be directed to the Chief, Resources Analysis Branch, OGI, 25X1

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Samotlor Oilfield: Prospects for a Fading Supergiant

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Summary

Information available as of 1 August 1983 was used in this report.

Samotlor—the flagship of the Soviet oil industry—is the USSR's largest and most prolific oilfield. Production from this supergiant grew from a modest 15,000 barrels per day (b/d) in 1969 to a peak of nearly 3.2 million b/d in 1980. The field was singularly responsible for the spectacular growth in Soviet oil production in the 1970s and at its peak accounted for 25 percent of national production and about 50 percent of West Siberian output.

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Samotlor's production is now declining.

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Our engineering analyses indicate that—in spite of the massive investment effort that the Soviets are now making in the field in the form of drilling and fluid lift—future annual declines could range from 10 to 15 percent. If so, production could easily drop

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The Soviets are attempting to slow the rate of decline temporarily with an expensive gas lift system purchased from France and augmented with equipment from Japan. Analysis

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shows that installation of the gas lift system has fallen far behind schedule and that the system is plagued with serious operational problems. Even if the Soviets succeed in getting the entire system installed and running properly, our reservoir simulations suggest that the best they can do is halt or moderate the current decline for a year or two.

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Samotlor's waning performance highlights the fundamental dilemma Moscow will increasingly face as the decade progresses. The field has joined the growing list of large giant and supergiant Soviet fields that were the mainstays of the Soviet oil industry during the last two decades but whose outputs are now faltering. To the extent that the Soviets plan to avoid any downturn in national oil production this decade, they must simultaneously:

- Continue increasing their investment in these aging but essential fields to keep ongoing declines to a minimum.
- Commit themselves to a massive effort, particularly in West Siberia, to find and develop enough smaller—and usually less productive—fields to offset lost production from the mature giants.

To date, Moscow has been succeeding at this, though at enormous and spiraling cost. With Samotlor now in decline, however, the task can only become more difficult.

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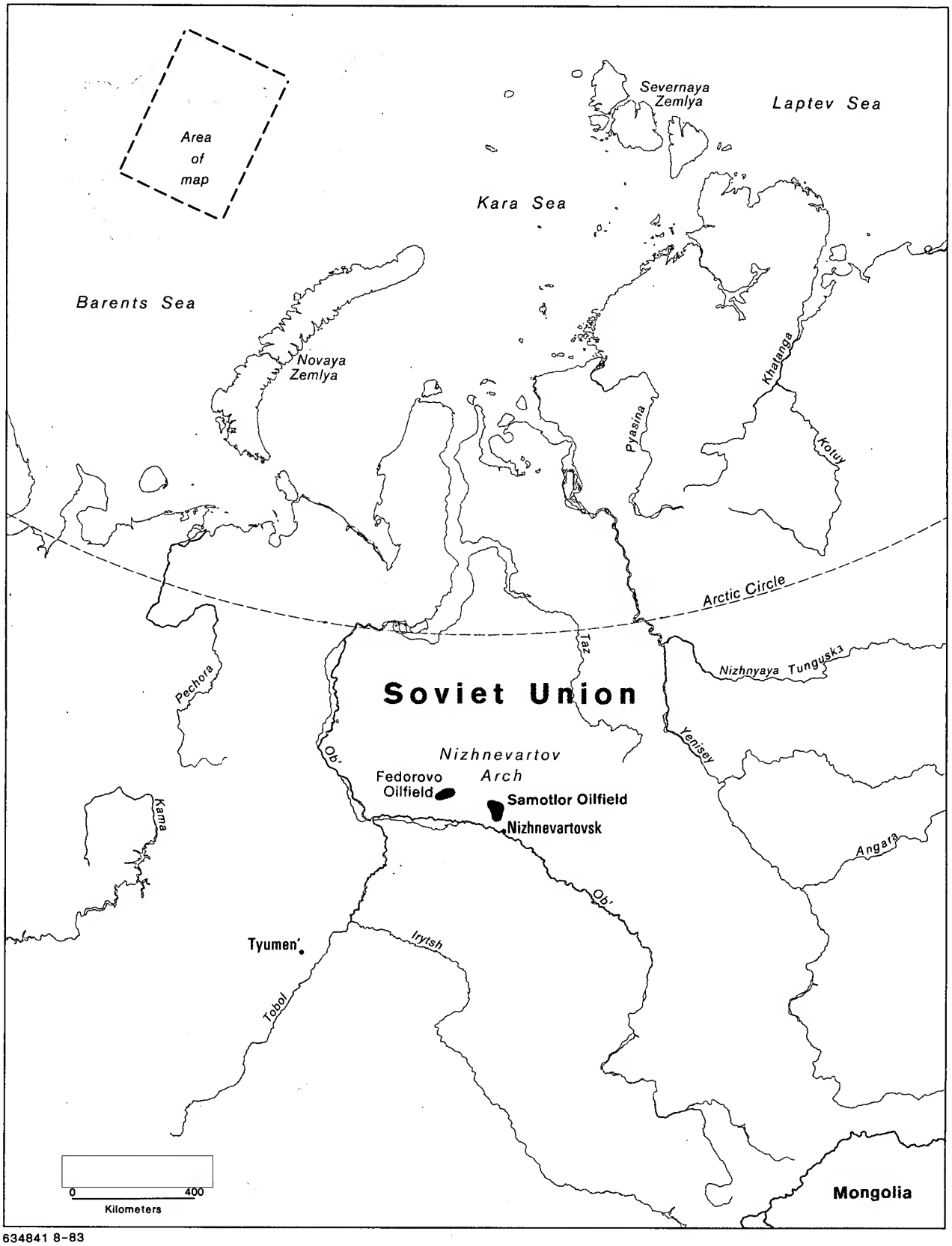
Figure 1

West Siberian Basin: Samotlor Oilfield



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Background

No Soviet oilfield—past or present—has had larger reserves or produced more oil in a single year than Samotlor. This immense supergiant in West Siberia probably contained recoverable reserves of more than 15 billion barrels [1] of oil when put into production in 1969 and still ranks easily as one of the 10 largest producing fields in the world.[2]

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During the 1970s Samotlor quickly became the Soviets' premier oilfield and was singularly responsible for the rapid growth in Soviet oil output during that decade. By 1980 Samotlor was yielding about 25 percent of total Soviet oil production and accounted for about 50 percent of West Siberian oil output. In the three years since, however, the role of Samotlor has waned while the relative contribution of the other fields in West Siberia has rapidly increased.

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Until recently, Western analysts were confused by the post-1977 production record for Samotlor. This confusion came about because of the management structure for the field—which is split between two separate production associations—and the deliberate vagueness and ambiguities in Soviet statements.

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we are now reasonably sure that production from Samotlor peaked at the end of 1980 and has continued to decline in spite of Soviet intentions to keep output growing through 1986.

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Field Development

The Soviets discovered Samotlor in 1965 when crews struck oil while drilling an exploratory well on the massive Nizhnevartov dome in the middle Ob' region of West Siberia. Seismic work had earlier delineated this very promising hydrocarbon trap. Complex logistic problems associated with the harsh climate and geography of West Siberia, however, delayed completion of the first production well until 1969. The developed field now covers some 1,000 to 1,500 square kilometers—a little more than half the size of Rhode Island (figure 3).

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[1] The Soviets measure oil reserves and production in tons. For convenience—and in keeping with oil industry convention—this report uses barrels, with 1 ton of oil, on the average, equaling 7.3 barrels.

[2] Most Western estimates (including those derived from our engineering analysis) tend to cluster around 15 billion barrels, a figure that agrees with most Soviet estimates.

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Samotlor has proved a far richer producer than the Soviets anticipated. As development drilling progressed, estimates of the recoverable reserves for the field grew, eventually converging on a figure of about 15 billion barrels. Estimates of projected maximum yearly production—as reported in the Soviet open press—also climbed from 2 million b/d in the early 1970s to 3 million b/d by late 1979.

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Soon after production operations commenced, the Soviets began using water injection, a management scheme designed to maintain reservoir pressure in order to increase initial oil production from the field. Although commonly used in the Soviet Union and effective for rapidly fulfilling production quotas and minimizing the early need for pumps, this practice can damage a newly producing reservoir and reduce ultimate recovery from the field. The Soviets compounded the problem by using untreated water from the three large lakes at the field rather than water treated to make it compatible with the connate water already in the reservoirs.[3] Western oil companies usually apply the water-flooding technique as a secondary—rather than primary—recovery method after a field has been in production for some time, and then only with specially treated water.

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To boost production even further, the Soviets also began an accelerated drilling program aimed at rapidly completing wells to the five major oil-producing horizons of the field.

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by mid-1981 the Soviets had drilled some 3,500 production wells and another 1,000 injection wells.

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As development has progressed, they have introduced both high-capacity rod and submersible pumps, and have also initiated an extensive gas lift program for the field.

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Recent Production History

Production at Samotlor rose rapidly during the 1970s, reaching about 2.2 million b/d by 1976.[4] By 1977 production stood at approximately 2.6 million b/d and substantially exceeded the original Soviet projections for the maximum capacity of the field. At that time, various authoritative Soviet journals reported that the field "had reached its production level." In 1978, however, production rose again to 2.86 million b/d. The Soviets apparently believed that this, too, was a maximum

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[3] Improperly performed waterflooding—particularly as was the case here—poses serious problems for a field like Samotlor, whose clays swell on contact with the water and clog sections of the reservoirs. (S)

[4] This is the consensus of most reliable sources, but a sign at Samotlor, photographed in 1981, showed this figure to be 101 million tons annually—or roughly 2 million b/d.

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As production from Samotlor—as well as that from one or two smaller satellite fields—is included in the totals of these two associations, production for Samotlor in 1981 and 1982 must have been lower in both years. Indeed, based on our analysis of the relative shares these two associations have contributed to the production of Samotlor in the past, we conclude that total output was between 3.04 and 3.08 million b/d in 1981 and between 2.84 and 2.88 million b/d in 1982.

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The decline may have taken Soviet planners by surprise.

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Their

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expectation was probably reinforced by the anticipated completion of a French gas lift system that they hoped would boost production from the nearly 1,300 gas-assisted wells by about 30 percent. A number of Soviet press announcements stated in 1981 that the field had just produced its billionth ton of oil, and would yield its second billionth ton within six years—implying that output would average at best 3.3 million b/d over this period. Similarly, in March 1981 Western visitors to Samotlor were told by its chief engineer that production would presently level off at 3.1 million b/d (presumably down somewhat from the 1980 peak) and hold steady through 1985.

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Coping With the Decline: Gas Lift and Drilling

The Soviets apparently hope to slow the decline in production through use of the gas lift system purchased from France and continuation of a program of mechanical pumping and drilling both of infill—or reduced space [5]—wells and of new wells on the less productive periphery of the field. The gas lift installation, an ambitious and expensive project involving

Samotlor: Disguising the Production Decline

The symbolic value of Samotlor to their oil industry probably makes the Soviets reluctant to publicize the ongoing decline at the field. With this in mind, we believe the Soviets might be tempted to disguise the magnitude of the decline at Samotlor by changing their format for reporting its production to include output from adjacent, satellite fields or by enlarging the boundaries of the field beyond their original limits.

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In the case of Samotlor, this would not only be convenient statistically, but might also have a geologic justification, albeit a tenuous one. The geology of the middle Ob' region of West Siberia probably makes the main oil-bearing horizons at Samotlor and the other fields in its vicinity continuous, although not necessarily productive throughout.[a] Under such circumstances, a strict delineation of Samotlor or most other middle Ob' fields is somewhat arbitrary and largely dependent on the field operators' ability to locate precisely the oil-water contact for each reservoir.

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Changes in reporting or field boundaries would make the production situation at Samotlor look healthier but would add nothing to the total oil contribution that the production associations make to national oil supplies.

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[5] This approach is commonly used in very mature oilfields and involves drilling new wells between existing wells to tap pockets of oil bypassed by the waterflood.

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nearly 1,300 wells, has run into a series of problems and lags several years behind schedule.

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25X1 Most of the problems seem to be a result of Soviet inexperience and unfamilarity with the equipment and technology combined with alleged shortcomings in the automated control system for the compressor stations. The Ministry of Petroleum Industry has made repeated attempts to speed gas lift conversion, including firing the production chief in charge of administering the program and turning to Japan for supplementary equipment.

25X1 the gas lift installation continues to proceed very slowly.

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The delay in gas lift installation is probably only one of many reasons for Samotlor's failure to reach the production goals for 1981 and 1982. The Soviets attempted to compensate for the gas lift failure with a stepped-up drilling program and mechanical pumping program, but evidently could not marshal the resources to halt the field's decline. Our engineering analysis now indicates that the Soviets must continue a high rate of drilling and pump installation and get the entire gas lift system installed and working properly if they are to have any chance at slowing Samotlor's rate of decline. In the meantime, the longer the system is delayed, the more other problems—like the rapidly rising field watercut, reservoir damage, and perennial reliability problems with mechanical pumps—will combine to depress production further.

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Future Production Possibilities

Our engineering and geologic analysis indicates that Samotlor's remaining recoverable oil should be from 5 to as high as 10 billion barrels—out of an original total of roughly 15 to 20 billion barrels—depending largely on what geologic boundaries are assumed for the field. When these figures are mated with Soviet data on the rock and fluid properties of the main reservoirs, the production history of the field, and alternative assumptions about the most likely pace of future development—in the form of new well completions and additional artificial lift equipment—we can estimate a range of possible values for the field delivery schedule over the rest of this decade

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Our estimate is bounded by two limiting cases that assume a high and low value for geologic reserves and well completions. Under the more favorable geologic and development circumstances—the high case—the best the Soviets could do would be to hold Samotlor's production at a plateau near its current rate of output through about 1985. By 1990, however, production would have fallen by more than 40 percent since 1982—to about 1.7 million b/d. We believe this is a very optimistic case and probably the less likely one, particularly in view of the Soviets' inability to get the gas lift system on track and substantially increase drilling. Under the less favorable circumstances—the low case—production would drop much more rapidly,

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falling to about 1.6 million b/d by 1985 and perhaps as low as 900,000 b/d by 1990. While this latter case is pessimistic, it is probably closer to the actual production course the field will follow.

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In any event, the performance of the field will hinge on two unknowns: the amount of oil left in the field and, even more important, the size and effectiveness of the additional investment the Soviets are willing to make in Samotlor. The outcome, therefore, probably will lie somewhere between the Soviets' ambitious goal of maintaining production at a relative plateau between now and 1985 or 1986 and the results of our more pessimistic modeling case. Our best estimate of future production would suggest that, after several years of reasonably shallow decline, production at Samotlor will fall fairly rapidly—by some 10 to 15 percent annually—by the end of this decade. Accordingly, output from Samotlor would probably stand somewhere in the vicinity of 2 million b/d by 1985 and close to 1 million b/d by 1990.[6]

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Based on our engineering analysis—and irrespective of which of the reserves and investment scenarios is projected for the field—we can draw a number of reasonably firm conclusions about the future of Samotlor:

- The original Samotlor deposit will continue to decline. By 1990 the Soviets will need to find other sources to replace the 1 million b/d—and, more likely, 2 million b/d—of production that Samotlor will have lost since 1982. In other words, the annual loss the Soviets would have to make up by 1990 could easily equal the entire amount of Soviet oil exports to Eastern Europe, or about two-thirds of Mexico's current oil production. By the year 2000—with a watercut approaching 95 percent—the useful economic life of the field will be close to an end.

- At the very best—and assuming the gas lift and drilling problems can be quickly corrected—Moscow probably will be able to moderate the rate of decline for no more than a few years more. By pushing production to the limits of field capacity

Our Analytic Approach

The Soviets have not published detailed field production data for some time, particularly for the major oilfields like Samotlor. The little information they have made available has usually been conflicting or simply not credible. To make matters worse, the Soviets treat data concerning their oil reserves as a state secret; consequently, we do not know for certain what they currently believe Samotlor's reserves to be.

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To overcome this lack of information, we have developed methodologies that permit us to estimate current production and reserves at major Soviet oilfields and to project future yields under alternative development scenarios. Our approach involves the application of advanced techniques of geologic and reservoir engineering analysis

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The validity of these methodologies rests on the fact that the behavior of an oilfield and its reservoirs is governed by a set of fundamental physical laws.

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Over the past five years, we have performed reservoir engineering simulations of Samotlor on a number of occasions.[a] Despite the fact that there are probably more technical data available on Samotlor than any other Soviet oilfield, the sheer size and complexity of the field, combined with the absence, until late 1982, of a reliable series for recent production, introduced considerable uncertainty into the analysis—and particularly into that done prior to 1982. The results reported here summarize a consensus of judgments from the earlier studies, updated by the findings of the most recent simulations.

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early on through an aggressive water injection program, the Soviets have not only caused reservoir damage but have also limited ultimate recovery and substantially raised the effort—and cost—required to prevent a steep decline. This, in fact, is what has happened at most other large Soviet oilfields and represents the price the Soviets have paid for emphasizing rapid, near-term growth in production rather than balanced field development. With the field peaking in 1980 and having produced possibly 50 percent or more of its reserves, it will be very difficult to hold production at a relative plateau for more than a few years beyond peak.[7]

- Continued high rates of drilling and new well completions and successful completion of the gas lift system will be essential to minimizing the rate of decline and keeping production in the higher portion of our forecasted range. By the end of the decade, however, Samotlor's production probably will be only fractionally higher with the gas lift than it would have been without it. Put simply, over the next seven years, the Soviets will be committed to a large and accelerating investment in drilling and fluid lift equipment just to keep production from falling too low too fast.[8]

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Outlook

The situation at Samotlor epitomizes the oil challenge Moscow faces over the rest of this decade. With production from Samotlor falling, every barrel of oil less that the field produces is one more barrel the Soviets must find and produce elsewhere if they are to avert a downturn in national oil production this decade—

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[7] In theory, an oilfield can be held near its peak production level until as much as 60 to 70 percent of its reserves has been depleted. This assumes, of course, healthy reservoirs and full-scale drilling and fluid lift programs. In practice, the limiting percentage is often lower—as would probably be the case at Samotlor, where water injection began almost simultaneously with production and improper development and field operating practices have caused reservoir damage

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[8] Gas lift is essentially a replacement for mechanical pumping rather than a form of enhanced recovery that would increase the ultimate yield of the field. Successful completion of the gas lift system would initially raise daily production from Samotlor and permit it to remain at a relative plateau for several years thereafter. Subsequently, however, the decline would continue, but at a higher rate than had gas lift not been used.

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Thus far, the Soviets have managed to do this by developing a number of much smaller fields in West Siberia and several giant fields in Tyumen.

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Although these smaller fields contain sufficient reserves to expand production in West Siberia, the costs—in terms of development time and of real resources like labor, drill rigs, pumps, and support infrastructure—are much higher relative to oil output than for an established supergiant like Samotlor.

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Although the ongoing decline at Samotlor by itself, may not make or break the Soviet oil industry, it graphically illustrates the dilemma in which the Soviets now find themselves. Because of the way in which the field was developed, the industry is committed to an accelerating and very expensive investment effort to minimize the decline of Samotlor. In the absence of the discovery and rapid development of a new Samotlor—an eventuality we judge possible but not likely on the basis of our geologic analysis—the alternative is an even larger investment in developing newer but smaller fields. In either case, the costs are high and increasing. The strength of the Soviet oil industry has been its ability to make such an effort in the past. The potential weakness is that, given the enormous size of the continuing investment required, Moscow may no longer be able to foot the entire bill and accomplish other essential tasks in the economy.[9]

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[redacted]